ORIGINAL ARTICLE

Non-firearm weapon use and injury severity: priorities for prevention

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Objectives: To test the hypothesis that weapon-related violence (excluding firearms) results in more severe injury relative to the use of body parts (fists, feet and other body parts), and to rank order of injury severity by assault mechanism.
Design: Retrospective cohort study.
Participants: 24 660 patients who were treated in a UK emergency department for violence-related injury.
Main outcome measure: Score on the Manchester Triage Scale.
Results: The use of a weapon resulted in significantly more serious injury (adjusted odds ratio (AOR) 1.13, 95% confidence interval (CI) 1.00 to 1.28). However, of all mechanisms of violent injury, the use of feet resulted in most severe injury (AOR 1.41, 95% CI 1.17 to 1.70), followed by blunt objects (AOR 1.35, 95% CI 1.14 to 1.58), other body parts (AOR 1.22, 95% CI 1.06 to 1.40) and sharp objects (AOR 1.09, 95% CI 0.91 to 1.5), compared with use of fists.
Conclusions: Use of weapons resulted in more severe injury than use only of body parts. The use of feet caused the most serious injuries, whereas the use of fists caused the least severe injuries. Injury severity varied by number of assailants and age of the patient—peaking at 47 years—but not by number of injuries. Preventing the use of feet in violence, and preventing group violence should be major priorities.

Interpersonal violence is a major cause of morbidity and mortality worldwide. It has been estimated that there were 520 000 homicides in 2000 globally, with an overall age-adjusted rate of 8.38/100 000 of the population.[1] Weapons play a large part in inflicting violent injury. Estimates suggest that in 1992, the cost of gunshots in the US alone was about US$126 billion, whereas cutting or stab wounds cost a further US$51 billion.[2] Despite the known relationship between weapon use and likelihood of injury,[3] to date, studies have focused largely on the role of firearms in injury data from the US. In much of the rest of the world, firearm availability and use are much lower, limiting the generalizability of US weapon studies to other international populations. For example, firearms are involved in about 70% of all the US homicides,[4] whereas government statistics for England and Wales indicate that the use of a sharp object is the most common mechanism of homicide (29%), with firearms accounting for only 9%.[5] In 2004, firearm use was associated with about 1% of all violent crime in England and Wales, whereas total weapon use in violent crime for the same period was around 22%.[6]

International literature related to assault mechanism and non-fatal injury is lacking. International rates of non-fatal injury by assault mechanism are not available, although rates of lethal injury by assault mechanism are available. Fingerhut *et al*[7] provide a description of the distribution of lethal assault mechanism for 11 countries. Among these first-world countries, rates of homicide by cutting or piercing range between 0.2 (France) and 1.1 (US) per 100 000. Rates of homicide by firearm range between 0.1 (England and Wales) and 5.9 (US) per 100 000. Therefore, there is much to be gained, from an international perspective, from studying assault mechanism and injury severity. As a first step, and the purpose of this research, injury data from emergency departments where the mechanism of injury is routinely recorded need to be used to rank severity. Inter alia, standard, routinely used measures of injury outcome need to be scrutinised to identify a measure that can easily be applied universally.

Two measures describe the seriousness of weapon use in violence: incidence and injury severity. Incidence describes the frequency with which a weapon is carried, use is threatened and injury is inflicted.[8 9] In the UK, the incidence of use can be calculated from crime surveys,[6] police data, and also from emergency and trauma services.[10 11] However, for public health practitioners, the incidence and severity of injury informs policy decisions: resources are targeted at agents causing the greatest harm to the greatest number; thus, our focus here is solely on Violent injury requiring treatment in an emergency department. Public health decisions on weapon use are incomplete without information on patient injury severity by assault mechanism. US data indicate that greater injury results from violent incidents involving any type of weapon than when no weapon is used,[3] an assertion that has not been tested elsewhere.

Although studies of injury severity according to weapon type are sparse, several studies have documented the characteristics and circumstances of injury caused by glass.[12–14] For example, in the UK, between 8% and 13% of patients assaulted and treated in emergency departments have been injured with glasses and bottles.[15–17] Also, drinking glass-related injury leads to considerably higher compensation awards than bottle-related injury, reflecting greater likelihood of eye and face injury with glasses than bottles.[12] Furthermore, in the UK, Shepherd *et al*[15] showed that patients who were kicked or injured with a sharp object were more likely to be admitted to hospital (an indication of greater injury severity). Elsewhere in Europe, Brink *et al*[18] reported that almost twice as many Danish patients were treated in emergency departments after penetrating trauma (10.3%) than blunt trauma (5.5%). Although a few studies have focused on specific assault mechanism, a wider perspective facilitating a comparison of injury by assault mechanism has not been conducted. For example, the physical harm

Abbreviations: MTS, Manchester Triage Scale; PMS, Patient Management System.

Table 1 Description of variables

Variable type	Description	n (%)
MTS	5 scores of clinical priority assigned by triage nurse (coded as a 5-item ordinal scale):	21123
	1, immediate	49 (0.23)
	2, very urgent	322 (1.52)
	3, urgent	3552 (16.82)
	4, standard	17133 (81.11)
	5, not urgent	67 (0.32)
Sex	Male (0, 1)	18507 (74.52)
	Female (0, 1)	6329 (25.48)
Injury information	Loss of consciousness (0, 1)	567 (2.39)
Admission	Patient admitted to hospital (0, 1)	1235 (5.04)
Weapon used	Weapon used to inflict injury (0, 1)	3645 (21.53)
Assault mechanism	Blunt object used to inflict injury (0, 1)	1782 (10.52)
	Sharp object used to inflict injury (0, 1)	1863 (11.0)
	Feet used to inflict injury (0, 1)	1184 (6.99)
	Fist used to inflict injury (0, 1)	9436 (55.73)
	Other body part used to inflict injury (0, 1)	2667 (15.75)
No of assailants	One assailant involved (0, 1)	9888 (62.01)
	Two assailants involved (0, 1)	1966 (12.33)
	Three or more assailants involved (0, 1)	4093 (25.67)

MTS, Manchester Triage Scale.

generated by the use of body parts to inflict injury has not been compared with that generated by non-bodily weapons. This is an important omission, as this information is necessary to devise coherent violence-prevention strategies.

The goals of this research are therefore twofold: firstly, to determine whether, in cases of violent injury treated in emergency medicine, weapon use results in more severe injury compared with the use of body parts—principally the head, knee, teeth, fist or feet; secondly, a rank order of injury severity was sought, on the basis of the assault mechanism used to inflict injury. Although the implications of these findings are discussed, and consequential recommendations for enhancing violence prevention made.

METHODS

Study population and design

A retrospective cohort study design was used. Cardiff was selected because it is a cosmopolitan European capital city served by one emergency department, in which routine data on the circumstances of violence—including assault mechanism—are collected. Furthermore, the score of the patient on the Manchester Triage Scale (MTS) is recorded routinely. The data studied were derived from the Emergency Department, University Hospital of Wales, Wales, UK (catchment population, 2004, 1.5 million) Patient Management System (PMS) from 22 March 1999 to 31 March 2005. The study was approved by the South East Wales Local Research Ethics Committee.

Main outcome: measuring injury severity and triage category

Measures of injury severity include the Abbreviated Injury Scale[19] and the Trauma Injury Severity Score.[20] Use of such instruments is time consuming and requires trained staff, which restricts their use to a limited sample size, even when using software such as the ICDMAP-90.[21] For this reason, large-scale, assault-related epidemiological studies rarely include injury severity assessments, focusing more on injury incidence. One potential means of defining injury severity is the use of triage scales such as the MTS.[22] The MTS is used in many European emergency departments for classifying patients according to clinical priority. The process of triage was designed to ensure that limited medical resources are directed to those in greatest need.[22] Patients in incident and medical settings are usually assigned a triage score by a nurse on the basis of injuries and subjective level of pain.[23] There are five triage categories (clinical priority hereafter) in the MTS: 1, immediate; 2, very urgent; 3, urgent; 4, standard; and 5, non-urgent.

The MTS has been used to good effect as a proxy measure of injury severity in road traffic accident victims,[24 25] in studies of post-traumatic stress, and has been found to predict, with some precision, patients who later require admission to critical care.[26] It is therefore possible that the MTS is a valid and practical measure of injury severity, as it takes into account factors, such as pain, which are absent in purely anatomical descriptors (K Mackway-Jones, personal communication, 19 August 2005).

Data collection and predictor variables

Emergency department reception staff recorded demographic information, violence location, day, time, number of assailants, injury location and assault mechanism. High specificity and sensitivity of recording in this setting has previously been established.[27] Triage nurses recorded triage category. An initial dataset detailing 25 274 assault-related cases was produced. The type of weapon or body part used was coded under an ''assault mechanism'' variable. Weapons were coded within this variable as either ''blunt object'' or ''sharp object''. The bodily mechanism options used were ''fist'', ''feet'' or ''other body part''. The term ''other body part'' referred to any part of the body other than fist or feet used in inflicting injury. Table 1 gives a description of the data.

Age was recorded as a continuous variable. Owing to low numbers of observations for people aged $\geqslant$75 years, all patients $\geqslant$75 years (187) were excluded. To account for potential non-linearities in age, a second-order polynomial of the form $y = ax+bx^2$ was entered into the analyses.

Before the analyses were conducted, the data were screened for inconsistencies across individual records and for missing data. Inconsistencies were typically diagnosis descriptions, which were not consistent (eg, men with obstetric problems), and injuries that were not consistent with assault (eg, insect stings and substance ingestion or overdose). This resulted in 427 cases being omitted, leaving a sample of 24 660.

Statistical analyses

Variables for inclusion in the models were selected based on a combination of earlier research, established knowledge and familiarity with the triage system. An ordinal logistic regression analysis was conducted to assess the relationship between triage score and the use of a weapon in causing the injury while controlling for several demographic and injury-related factors, which were selected *a priori* as possible confounders. Triage category was the dependent variable, whereas assailants' use of a weapon, age, sex, date, number of injuries, loss of consciousness and number of assailants were the independent variables. Covariates were added by forward inclusion. A further ordinal logistic regression was used to investigate the relationship between the MTS and assault mechanism—that is, weapon or body part used to cause injury, while also controlling for several demographic and injury-related factors. Again, triage category was the dependent variable, whereas feet, blunt object, sharp object, other body part, age, sex, day, month, year, number of injuries, loss of consciousness and number of assailants were the independent variables. All analyses were conducted using the Stata V.8 statistical package. Predictor variables were further screened for collinearity, and no comparison yielded a variance inflation factor >0.88, indicating that subsequent regression coefficients were not susceptible to this potential bias.

To determine the severity of injury associated with each assault mechanism, reliable measures of injury severity from emergency department records are required. Data for this purpose include the MTS score and hospital admission. It is assumed that being admitted to hospital is a valid proxy indicator of a severe injury.[15] A polychoric correlation coefficient was determined for the relationship between the ordinal variable MTS and the binary variable admission to hospital, $\rho = 0.56$, standard error 0.015. This result indicates close correlation between the two measures, showing that the MTS is a valid proxy measure of injury severity. It should be noted that this analysis is offered as validation for the MTS as a proxy measure of injury severity, and may not be as sensitive as the Abbreviated Injury Score or Trauma Injury Severity Score, observations for the calculation of which were not available.

RESULTS

The study sample was 24 660 patients who reported injury in assault, with a total of 31 315 injuries. Men accounted for 74.5% of the sample. Of the 21 440 injuries for which assault mechanism data were available, 21.5% were inflicted with a weapon, 11% of all injuries were reportedly inflicted with a sharp object and 10.5% were inflicted with a blunt object. The category of assault mechanism with highest incidence was fists, accounting for 55.7% of all injuries, whereas 7% were inflicted with feet and 15.8% were inflicted with another body part. Most of the patients (81%) had one injury, 14.6% had two injuries and approximately 4.5% had three or more injuries. No significant difference was seen between numbers of injuries according to assault mechanism. In all, 62% of attendees reported being injured by just one person, 12.3% were injured by two assailants and 25.7% reported being injured by three or more assailants. A total of 41.1% of injuries were of the face, whereas other head or neck injuries accounted for a further 24.9%; 5.3% of injuries were of the thorax, 2.5% of the abdomen, 20% of the upper limb and 6.3% of the lower limb; 2.4% of patients lost consciousness.

Table 2 shows the results of the ordinal logistic regression analysis of triage category on the use of a weapon. The first, albeit unadjusted, model indicates that the use of a weapon was significantly more likely to result in greater clinical priority (adjusted odds ratio 1.205, $p<0.001$). Weapon use was more likely to result in serious injury than if a weapon was not used. The second model shows the final forward regression. Although being male was not markedly associated with more severe injury, this covariate was included in the analysis as it was thought that it could have an important effect on the results. Both terms of the age polynomial were significant, indicating a non-linear relationship between age and injury severity, in this case following an inverted ''U'' shape. Solving the first-order differential equation for 0 yields the age at which the probability of greatest injury occurs—in this case, likelihood of severe injury peaked at 47 years of age.

Mackway-Jones *et al*,[22] authors of the MTS, recommend that patients with altered levels of consciousness are treated immediately and so this was controlled for in the analysis. Reflecting this recommendation, a loss of consciousness was significantly related to increased severity of injury (OR 8.821, $p<0.001$). The number of injuries did not affect the model significantly and was dropped from the analysis. The model indicated that the injuries inflicted by three or more assailants were significantly more severe compared with the injuries inflicted by a lone assailant (OR 1.378, $p<0.001$). However, no significant difference in injury severity in the transition from one to two assailants was observed.

Table 3 shows the results of the second ordinal logistic regression of triage category on assault mechanism, patient and injury-related variables. The unadjusted model, model 1, showed that, compared with being injured with a fist, the use of blunt objects, feet, sharp objects and other body parts was considerably more likely to result in severe injury. Despite the finding that the use of a weapon was likely to result in more severe injury than non-weapon use, the results show that the assault mechanism most likely to result in more severe injury was the use of the feet. The second model indicates that sharp objects were not significantly more likely to result in serious injury than fists when number of assailants exceeds one.

DISCUSSION

As hypothesized, the use of a weapon was markedly associated with increased injury severity. This is consistent with the findings of Felson and Messner,[3] who showed that injuries from violent incidents are more likely to be severe when offenders use any type of weapon. Further statistical investigation showed that the use of feet resulted in greatest injury severity in this large sample. In contrast with previous findings,[15] the use of blunt objects, rather than sharp objects, was the next most likely to result in severe injury.

The finding that sharp objects are less likely to result in severe injury than feet, blunt objects or other body parts is noteworthy, as sharp objects are the most often used objects of homicide in England and Wales. These findings may reflect a failure of the data to discriminate between, for example, knives, which can be used to inflict severe penetrating trauma and other sharp objects, for example, broken glasses and bottles—the use of which may result in comparatively superficial wounds.

The proportion of women (25.5%) who attended the emergency department for treatment of violence-related injury was higher than in earlier UK studies,[15 28] which may reflect cultural and sex expectation changes. However, owing to missing data for the response option ''assault mechanism'', comparisons cannot be made between incidence of weapon use in this dataset and other studies.

The relationship between age and injury severity is non-linear, forming an inverted U-shaped curve: people aged about 47 years were at the greatest likelihood of more serious assault injury. This may reflect increasing physical vulnerability owing to age, coupled with risky behaviors in risky environments not typically displayed by older people. Preliminary models not reported here, but available from the authors, showed that men were considerably more likely to

Table 2 Results of an ordinal logistic regression to investigate the relationship between weapon use in violence and triage category

	Model 1		Model 2	
Triage category variable	Unadjusted odds ratio (95% CI)	p Value	Adjusted odds ratio (95% CI)	p Value
Weapon	1.205 (1.086 to 1.338)	<0.001	1.133 (1.001 to 1.282)	<0.05
Age (years)			1.047 (1.025 to 1.07)	<0.001
Age squared			0.9995 (0.9991 to 0.9997)	<0.01
Male			1.020 (0.907 to 1.148)	0.737
Day			Yes	
Month			Yes	
Year			Yes	
Loss of consciousness			8.821 (6.962 to 11.177)	<0.001
Number of assailants (compared with 1 assailant)				
2 assailants			1.112 (0.948 to 1.305)	0.190
⩾3 assailants			1.378 (1.228 to 1.547)	<0.001
Pseudo R^2	0.001		0.040	
Log pseudolikelihood	−7524.5045		−5738.4136	
n	14440		12608	

be more severely injured than women, although this was not the case once the number of assailants was included in the analysis (model 2). This suggests that larger groups are less discriminating of sex than lone assailants. This may also reflect a tendency for women to fight in groups. Social psychologists have found that the elicited aggression of an individual is increased by salient group membership.[29]

The regression analyses involved two models owing to the complex nature of violent injury and its varying contexts. The inclusion of the "number of assailants" variable also had an effect on the relationship between injury severity and assault mechanism. This suggests a complicated relationship between fighting in groups and weapon use, possibly owing to a variation in the contextual or cultural nature of different forms of violence, such as domestic violence and alcohol-related street violence. The significantly greater likelihood of severe injury when three or more assailants were involved supports findings that, among adolescents, fighting in groups increases the likelihood of severe injury.[30]

Some limitations deserve mention. A lack of longitudinal data limits the reliability of comparisons with previous studies. However, the similarities between Shepherd's UK findings,[15] those of Brink *et al*[18] in Denmark and those in this study, suggest some consistency in the incidence of assault mechanism across the three studies, and across Western Europe. Nonetheless, as assault mechanism relates partly to culture and fashion,[31] the results of this study may not be generalizable to cultures outside the UK. Despite this, the study provides interesting findings relating to the nature of group violence, which should be investigated more widely. Selection bias may be a problem in this study. The fact that the patient has been treated in an emergency department suggests that the injury is above a particular threshold of severity or pain while not being fatal; fatal and less serious violent injuries occurring in the base population are not included in the analyses. Although triage score was found to be a useful proxy measure of injury severity, a limitation is that triage score is assigned before a detailed examination of the patient, and consequently some injuries may, at first, go unnoticed. Although, in this study, MTS has been found to predict admission, further validation exercises using more established measures of injury severity need to be undertaken.

In terms of the international relevance of this study, a routine indicator of clinical priority, the MTS, has been found to be a useful indicator of injury severity. Furthermore, this study shows that information about the circumstances of injury in violence can be recorded reliably in emergency departments. Taken together, these observations indicate that emergency

Table 3 Results of an ordinal logistic regression to investigate the relationship between assault mechanism and triage category

	Model 1		Model 2	
Triage category variable	Unadjusted odds ratio (95% CI)	p Value	Adjusted odds ratio (95% CI)	p Value
Assault mechanism (compared with fist)				
Blunt object	1.407 (1.224 to 1.619)	<0.001	1.345 (1.142 to 1.584)	<0.001
Feet	1.435 (1.221 to 1.687)	<0.001	1.409 (1.1698 to 1.698)	<0.001
Sharp object	1.187 (1.024 to 1.376)	<0.05	1.09 (0.910 to 1.299)	0.356
Body part	1.197 (1.060 to 1.351)	<0.01	1.216 (1.059 to 1.397)	<0.01
Age (years)			1.048 (1.026 to 1.071)	<0.001
Age squared			0.9994 (0.9991 to 0.9998)	<0.01
Male			1.023 (0.909 to 1.151)	0.704
Day			Yes	
Month			Yes	
Year			Yes	
Loss of consciousness			8.818 (6.963 to 11.168)	<0.001
No of assailants (compared with 1 assailant)				
2 assailants			1.097 (0.935 to 1.287)	0.255
⩾3 assailants			1.349 (1.201 to 1.516)	<0.001
Pseudo R^2	0.003		0.042	
Log pseudolikelihood	−7511.4084		−5728.1394	
n	14440		12608	

Key points

- Assault injury severity peaked at 47 years. Assault by three or more assailants caused more severe injury than assault by one assailant.
- The use of weapons resulted in significantly more severe injury than non-weapon violence.
- In descending rank order, the use of feet, blunt objects, other body parts and sharp objects were significantly more likely to result in more severe injury than the use of fists.
- Injury prevention should focus on kicking and the use of blunt objects in violence.
- The score on the Manchester Triage Scale is a useful indicator of injury severity.

departments can provide unique insights of violence and that a public health approach is essential to complement criminal justice approaches. This provides justification for a cross-sectoral, partnership approach to tackling violence, not just in the UK but globally as advocated by the WHO.

Implications for violence prevention

This research sets an agenda for non-firearm violence prevention based on injury severity. This makes the prevention of kicking and group violence, as well as violence in which weapons are used, major priorities. This might be achieved through more severe criminal sanctions to deter kicking, and public awareness campaigns. A further study of the types of footwear associated with injury sustained by kicking may be instructive, as, in this context, footwear characteristics can be expected to determine injury severity—at least in part. Although no data are available on the extent to which the injured fell or were knocked over before they were kicked (and severely injured), it is likely that kicking becomes more probable in these circumstances. Therefore, an important priority is to reduce the likelihood of falling over in an assault. As the major risk factor for this in the UK and elsewhere is intoxication with alcohol, reducing the prevalence of drunkenness is also a major priority. Although falling over is inevitable in some assaults, it is possible that public education, through increasing knowledge of the risks involved, can influence this. There are, of course, many examples of behavior change in response to a combination of educative and criminal sanctions, drunk driving being the most obvious.[32]

A second implication of this study is that, at least in a UK context, but probably more widely, the availability of blunt objects likely to be used as weapons should be restricted in those environments where violence is most likely—for example, in the street and in premises licensed to serve alcohol in city centers. Although this is a difficult task, it has been achieved in healthcare settings where some patients are known to behave aggressively.[33] Furthermore, object availability can be limited through frequent collection of bar glasses, for example, and through continuous litter collection and disposal in city centers. This health (injury) perspective of violence, surprisingly perhaps, gives a different prevention priority list than previous criminal law perspectives, which are concerned with intent and threat as well as actual harm. This is not to say, of course, that the prevention of firearm and knife violence should not be a priority, but that the prevention of kicking and the use of blunt weapons is equally important.

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